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LARGE AREA APPLICATION OF A CORN HAZARD MODEL

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CORN HAZARD MODEL FIRST ISSUE

A large area operational application of the Corn Hazard Model using real time data and evaluation of results.

1. REASON FOR ISSUANCE

Documents the first large area application of a Corn Hazard Model developed by T. W. Taylor and Francis W. Ravet, Early Warning and Crop Condition Assessment component of AgRISTARS. Large area application was conducted by CCAD with the support of EW/CCA AgRISTARS.

2. COVERAGE

This Technical Memorandum evaluates the operational application of the Corn Hazard Model, by CCAD, over the major corn for grain producing regions of the USSR during the 1980 growing season.

3. ACKNOWLEDGMENTS

Dr. T. W. Taylor and Francis W. Ravet, EW/CCA AgRISTARS for developing and documenting the model.

4. PREPARED BY·

Pat Ashburn, FAS, CP, CCAD	March 1981 Date
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PART 1.0
INTRODUCTION

1.1 SUMMARY AND CONCLUSIONS

In an effort to improve crop condition analysis capabilities used by the Crop Condition Assessment Division (CCAD) of the Foreign Agricultural Service (FAS), new and/or improved agricultural models are continuously assessed and tested over large operational areas for possible future integration into the operational system of CCAD. The Corn Hazard Model (CHM) developed and tested by the Early Warning/Crop Condition Assessment (EW/CCA) component of AgRISTARS is such a model. This hazard model which also estimates a corn crop calendar was run using operational data over the corn-for-grain producing regions of the Soviet Union. The model uses primary World Meteorological Organization (WMO) meteorological data elements, such as temperature and precipitation. Soils data interacts with the model through the use of soil moisture calculations. The model provides reports on geographic areas that are analyzed by the country analyst; thereby reducing the comprehensive analysis of many primary data elements.

An application test of the crop calendar portion of this hazard model was performed over the corn-for-grain producing regions of the Soviet Union during the 1980 crop year using real data. Success of the model was measured in terms of efficiency, accuracy, objectivity, repeatability, and continuity, with efficiency and accuracy receiving the highest considerations. Only the crop calendar portion was evaluated. Additional analysis of the hazard indicators will follow as time permits.

The general performance of the model as operated over the test area was very favorable. Efficiency gains in meteorological data analysis time were 85 to 90 percent.

Model results combined with Landsat data analysis were used to estimate the area and condition of the corn-for-grain in the Soviet Union for 1980. The results were in line with the recent area estimates and conditions provided by the U.S. Agricultural Counselor in the Soviet Union and with Soviet newspaper and radio accounts.

The Crop Condition Assessment Division (CCAD) will continue to use the Corn Hazard Model in the USSR and further evaluate its performance. We will also provide feedback to the Early Warning component of AgRISTARS on the results of our use of the model.

1.2 BACKGROUND

The Crop Condition Assessment Division (CCAD) of the Foreign Agricultural Service (FAS) is responsible for verifying and assessing

1.4 DATA SET

The primary corn-for-grain producing area of the USSR was selected as the test area for evaluation of the CHM. Temperature and precipitation data were extracted from World Meteorolgogical Organization (WMO) station data. Planting dates were extracted from radio and newspaper reports from the USSR. Soil moisture was derived from a soil moisture model that was run using WMO data and soil type for each WMO station for each day of data. In total 15 stations were used to evaluate the model.

Verification data were limited to FAS Agricultural Attache reports, official USSR reports, Soviet radio and newspaper accounts, and Landsat data.

PART 2.0
PERFORMANCE EVALUATION

2.1 EFFICIENCY

The general performance of the CHM operated over the USSR during 1980 was favorable. Efficiency gains in meteorological data analysis time were significant. Estimates of savings in time were on a magnitude of 85 to 90 percent.

The model evaluated a larger number of stations; thus, it significantly improved the analysis of the corn condition.

2.2 ACCURACY

Evaluating the accuracy of the CHM results were difficult due to a lack of confirmed ground observations. Accuracy evaluation was assessed using U.S. Agricultural Attache reports sent from the Soviet Union, Soviet newspaper and radio reports, and analysis of Landsat data.

Nine separate WMO stations (Figure 1) were selected across the grain producing areas. These stations are located to provide a full range of weather conditions experienced during 1980. They are also located to provide the full range of geographic conditions experienced in the major grain producing regions in the USSR. The CHM was given planting dates provided by CCAD analyst. These dates were provided by reports from the USSR. Where no planting dates were available, they were spread from other reporting stations.

A significant number of stations reported growth stages in a 10 day range. This is due to the type of reports from which the information was taken. These are decade reports published for each 10 day period. The CHM was considered successful when the growth stage was no more than 3 days outside of this range.

Grain is harvested in the USSR sometime after the beginning of the dent stage. The harvest is related more to weather conditions, lateness of the season, or a need to clear the field. Consequently, accurate growth stage reporting is clouded during the end of the year.

The hazard output of the CHM is difficult to evaluate due to a lack of good ground truth data. Without this, the results must be checked over a long period of time - probably more than one year. The hazard portion of the model is presently considered successful if it alarms an area when other information sources are indicating an alarm should be announced. For the 1980 data, the model seems to be setting flags where they should be set. However, additional information and time are required to adequately evaluate the hazard portion of the model.

The crop calendar portion of the CHM was highly successful in the USSR for 1980. The results shown in Table 1 were very encouraging. These indicated the model accurately operated over a very wide geographic area and over a wide range of very different weather conditions.

2.3 SUMMARY

The crop calendar component of a corn stress indicator model was evaluated using 1980 real time data for the corn-for-grain producing regions of the Soviet Union. Model success was measured in terms of efficiency, accuracy, repeatability and continuity. Verification data were FAS Agricultural Attache reports, official USSR reports, Soviet radio and newspaper accounts, and Landsat imagery. Use of the model resulted in a time saving for meteorological data analysis of 85 to 90 percent. A description of the model logic and components is included.

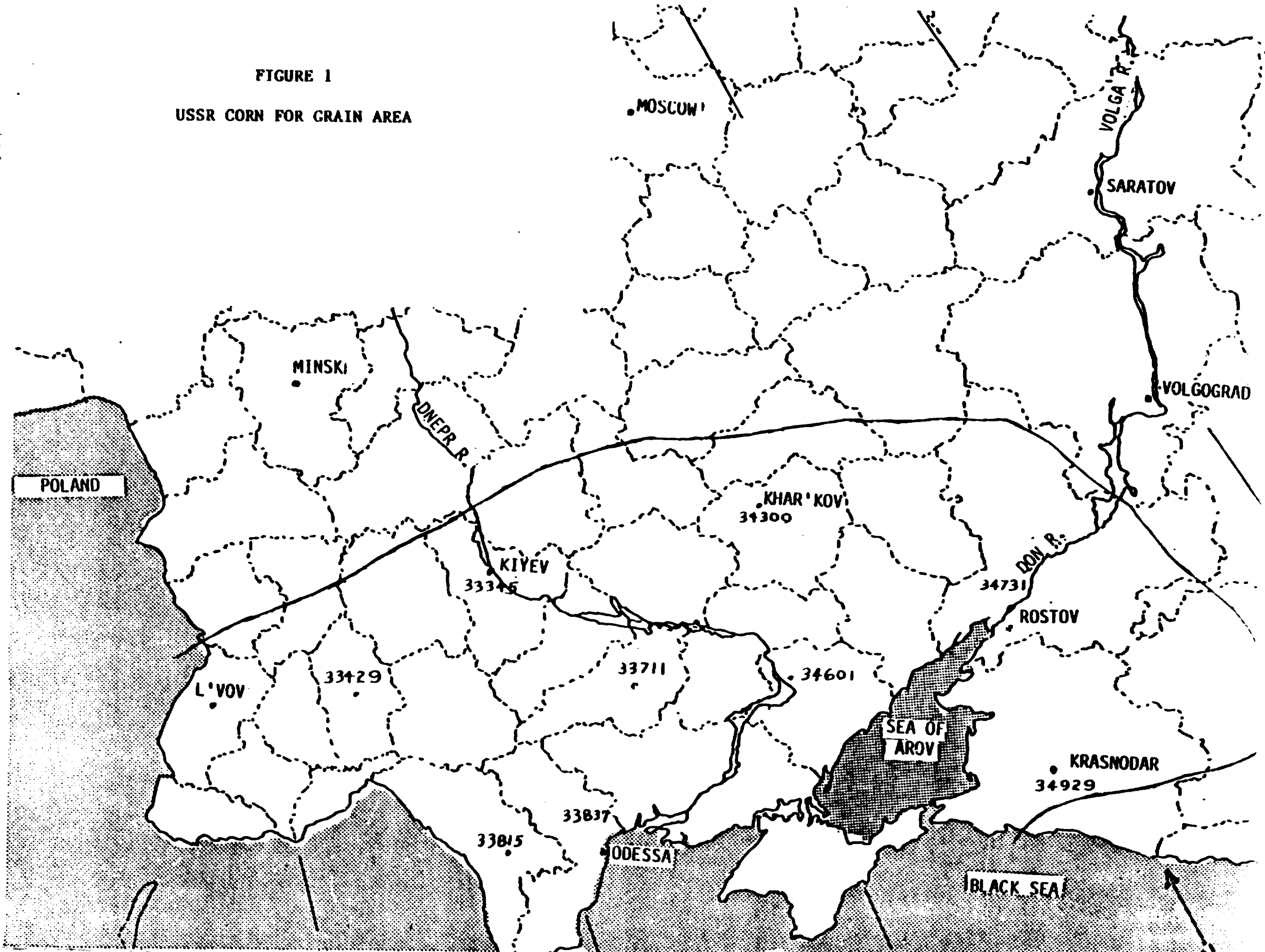
TABLE 1. ESTIMATED AND REPORTED CORN GROWTH STAGE IN THE USSR, 1980

STAGE GROWTH	WORLD METEOROLOGICAL ORGANIZATION STATION NUMBER																	
	34300		33345		33711		33815		34929		33837		34731		33429		34601	
	E	R	E	R	E	R	E	R	E	R	E	R	E	R	E	R	E	R
Planted		4/15		4/10		4/10		4/10		4/10		4/10		4/10				4/10
2 Leaves	6/5	6/10			6/1	6/10	5/28	5/20-30	5/21	5/20-30	5/28	5/20-30	5/24	5/20-30			5/28	5/20-30
6 Leaves							6/11	6/1-10	6/4	6/10	6/11	6/10	6/7	6/10			6/11	6/1-10
8 Leaves									6/11	6/14			6/14	6/14				
10 Leaves	7/14	7/1-10																
12 Leaves					7/9	7/1-10												
16 Leaves							7/13	7/1-10	7/4	7/5	7/10	7/1-10	7/6	7/5	7/25	8/1-10	7/11	7/1-10
Silk-Tassel	7/27	8/1-10	8/5	8/1-10			7/22	7/11-20	7/13	7/11-20	7/23	7/11-20	7/16	7/11-20			7/21	7/11-20
Blister Kernel					8/11	8/1-10									8/22	8/20-30		
Dough Stage	8/24	8/20-30	9/3	8/20-30	9/23	8/20-30	8/12	8/1-10	7/31	8/1-10	8/13	8/1-10	9/3	8/1-10			8/9	8/1-10
Begin Dent	9/8	9/1-10	9/16	9/14			8/26	8/20-30			8/24	8/20-30					8/23	8/20-30
Full Dent	9/27		10/15	10/4	9/22	9/1-10	9/7	9/14	8/21	8/20-30	9/6	9/14	8/24	8/20-30	10/11	10/10	9/6	9/14
Physio Mature		10/10			10/29	10/10	9/20	10/2	9/1	8/30	9/18	10/2	9/5	8/31			9/19	10/4

E = Estimated by Model
R = Reported

FIGURE 1

USSR CORN FOR GRAIN AREA



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APPENDIX A

DESCRIPTION OF CORN STRESS INDICATOR MODEL

PURPOSE

The purpose of this section is to document a corn hazard model that detects plant stress due to moisture deficiency and adverse temperatures. A brief synopsis of the climatic stress thresholds for corn (maize) at different growth stages is also given.

MAJOR VARIABLES

The degree of stress is dependent on three variables - phenological growth stage, available soil moisture and temperature.

PHENOLOGICAL GROWTH STAGE

The Hanway Growth Stage (HGS) system (Hanway, 1963) was used in the model as defined below:

HGS	PHENOLOGICAL STAGE
0.0	Emergence
1.0	4 Leaves
2.0	8 Leaves
3.0	12 Leaves
4.0	16 Leaves
5.0	Silk-tassel
6.0	Blister Kernel
7.0	Dough
8.0	Begin Dent
9.0	Full Dent
10.0	Physiological Maturity

During each stage optimum and stress conditions exist. Most of these conditions are directly related to meteorological factors. Stress was defined in this model version as those factors considered to most affect the maize growth cycle and for which input data are presently available to CCAD. Problem and optimal conditions that form the model logic are presented by growth stage in Table 1.

STRESS MODEL COMPONENTS

The stress model has 3 central components - a hazard model, a crop calendar model and a soil water budget model. These latter 2 models collectively require daily meteorological data - maximum and minimum temperature and precipitation. The phenology-based hazard routine contains the stress definitions and thresholds. The crop calendar is a fixed-increment degree-day model developed by EW/CCAD that requires an actual or estimated planting date. Degree-day summations are variety specific. A two-layer soil moisture model as modified by Ravet and Hickman (1979) is employed to track the amount of plant-available soil water.

DEGREE-DAY CALCULATION

Temperature is a regulator of maize growth and development. Most efforts to predict the timetable of maize development have used a heat-unit approach; the most common is the degree-day. The Brown method (1975) of determining degree days is based on the physiological response of plants to temperature and is determined as follows:

$$DD = (Ymax + Ymin) / 2$$

where $Ymax = (Tmax - 10^{o}C)*[3.33-0.084*(Tmax - 10^{o}C)]$ and $Ymin = 1.8 *(Tmin - 4.44^{o}C)$. When Tmax is less than or equal to $10^{o}C$ the value of Ymax is zero and when Tmin is less than or equal to $4.44^{o}C$ the value of Ymin is zero. When Tmax is greater than $32^{o}C$ the value of Tmax is $32^{o}C$.

The values of the accumulated degree-days for the most common Soviet Union variety are: 110 to emergence, 420 to HGS 1.0, 775 to 2.5, 1320 to 4.75, 1730 to 6.5, 2080 to 8.0 and 2565 to 10.0.

MODEL PARAMETERS AND OUTPUTS

The model identifies three environmental conditions - optimum, adequate and hazardous. Hazardous conditions include:

(a) Insufficient pre-season stored soil moisture
(b) Planting/harvest delay (tractability problems)
(c) Poor germination
(d) Poor emergence
(e) Adverse growing season soil moisture and temperature (excessive/deficient, phenology-based)

The stress indicator model determines the possibility of maize stress based on temperature and moisture conditions (see Table 1). The stress and optimal growth conditions are recorded for each growth stage as well as the time the plant remained in these stages. From this information the analyst can judge the degree of damage or stress occurring at a growth stage and then determine the overall effect on crop development. The model does not predict events nor does it attempt to assess the impact of stress; it provides information that indicates conditions occurring within a predescribed geographic area. The output from the model is a record of each day that a stress condition has occurred, the reason for the stress and the crop growth stage. At the completion of processing data for a given meteorological station, the data are summarized giving the total days for development, and the number of optimum and hazardous growth days.

EW/CCA DISTRIBUTION April 20, 1981

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